Research Results

Transportation Safety and Mobility

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Testing Proposed Parameters of the Dedicated Short Range Communications Platform

Performance analysis of factors that affect vehicular wireless communications

WHAT WAS THE NEED?

To increase safety, reduce collisions, and improve the efficiency of the country's roadways, the U.S. Department of Transportation (USDOT) has been exploring Dedicated Short Range Communications (DSRC) technology to support Intelligent Transportation Systems (ITS), such as the Connected Vehicle initiative. DSRC is a wireless communications system that enables vehicle-to-vehicle and vehicle-to-infrastructure (roadside) communications based on situational awareness. Each vehicle periodically broadcasts information about its location and other parameters to vehicles in its area, and possibly, to roadside units that can relay the information to traffic monitoring centers.

DSRC public safety applications can improve the safety and mobility of California roadways by reducing collision response times and generating in-vehicle warnings of road conditions, such as emergency vehicle activity, inclement weather, traffic congestion, and detours.

To ensure open, interoperable radio systems for DSRC, the USDOT embarked on a standards development program, choosing the Institute of Electrical and Electronic Engineers (IEEE) to produce physical and network radio standards. That effort is ongoing and in need of public sector input. The new IEEE Std 802.11™ 2012 includes DSRC 5.9 GHz functionality in the annexes and in sections that refer to outside the context of a basic service set.

To be effective, the vehicular network must operate under high load, extreme weather conditions, and unfavorable communication environments. In particular, when traffic is dense, the network must be able to handle the increased message volume with a high success rate. This research looked at factors that affect network performance in terms of public safety applications.

Warning drivers of roadwork ahead increases safety for maintenance operators.

WHAT WAS OUR GOAL?

The goal was to provide meaningful, empirically based input to standards developing organizations to help identify the optimal system architecture for DSRC to address multiple public sector scenarios, including using the high-power public safety channel in combination with lower power channels, traffic management during congestion, and locating vehicular incidents. An additional goal was to determine the optimal number of public safety channels for a given available bandwidth.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Los Angeles Cognitive Reconfigurable Embedded Systems (CORES) Laboratory, studied the performance of the DSRC physical layer—the radio hardware that generates and decodes the transmitted signals. The researchers also analyzed the network layer of the DSRC 5.9 GHz frequency band. Prior to investigating the scenarios, existing simulation algorithms were enhanced by testing them with more realistic assumptions.

The researchers characterized the packet error rate performance of a network compliant to IEEE 802.11p, the approved DSRC amendment to the IEEE 802.11 wireless network standard, as a function of several system and channel parameters. By considering specific applications and their requirements, the researchers evaluated how large the transmission packets should be to minimize errors and application latency. Various traffic densities were tested, with average vehicle separations of 5 meters, 10 meters, and 30 meters. The team investigated the impact of packet collisions on reception and characterized the probability of successful transmission as a function of transmission range for different transmitter power levels.

The researchers analyzed the effect of interference from adjacent safety, control, and service channels within the DSRC standard. They also explored localization algorithms for predicting and avoiding collisions based on estimating the relative distances between vehicles by analyzing the strength of the communication signals versus using Global Positioning System (GPS) data.

WHAT WAS THE OUTCOME?

The research quantified the achievable throughput for several modulation schemes of the channels in the 802.11p network. It was confirmed that interference increases as vehicle density rises. High transmit power (arbitrarily chosen as 23 dBm) works better in low and medium vehicle densities (30 meters and 10 meters, respectively). Low power (0 dBm) works better for high-density situations

(5 meters), because there is too much interference with higher transmit power. Simulations showed that larger packets had better throughput than small ones (tested with 250 bytes and 50 bytes, respectively) at all vehicle densities and power settings.

If a vehicle has two radio devices that are transmitting simultaneously on the public safety channel at higher power and on the neighboring channel, the researchers found too much interference. The interference can be decreased by avoiding or minimizing simultaneous communication on the channels. The research also revealed that localization based on analyzing the strength of the communication signal between vehicles is less expensive than using GPS data because extra hardware is not required. However, GPS-based localization is more accurate.

Future research tasks should focus on using the network models refined by this task to analyze other system parameters that affect specific public sector DSRC applications.

WHAT IS THE BENEFIT?

Wireless vehicular communication enables new ITS applications that improve public safety and and enhance traffic management. The effectiveness of the DSRC technology is dependent on cooperative standards for interoperability. This research contributes to the development of national and international standards that facilitate deployment of vehicle-to-vehicle and vehicle-to-roadside wireless communications, with an emphasis on public sector safety applications, such as work zone safety, first responder spectrum usage, probe data, and critical traffic information.

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To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2011/task_1228-tsm.pdf

DSRC applications can warn drivers of roadway emergencis and suggest detours.